The mid to long term outcomes of the Lateral Domed Oxford Unicompartmental knee replacement: An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man

Hasan R Mohammad, Gulraj S Matharu, Andrew Judge, David W Murray

Qualifications, appointments and roles of the authors

[1, 2] Mr Hasan R Mohammad - MBChB, MRCS, MRes (Dist). Clinical Research Fellow in Orthopaedics.
[1, 2] Mr Gulraj S Matharu – BSc (Hons), MRCS, MRes, DPhil. Clinical Lecturer in Trauma and Orthopaedic Surgery.
[1, 2] Professor Andrew Judge – BSc, MSc, PhD. Professor of Translational Statistics.
[1] Professor David W Murray – MD, FRCS. Consultant Orthopaedic Surgeon and Professor of Orthopaedic Surgery.

Institutional address

1. Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences University of Oxford, Nuffield Orthopaedic Centre, Oxford, OX3 7LD, United Kingdom
2. Musculoskeletal Research Unit, Bristol Medical School, University of Bristol, Level 1 Learning and Research Building, Southmead Hospital, Westbury-on-Trym, Bristol, BS10 5NB, United Kingdom.

Corresponding author:

Name: Mr Hasan Raza Mohammad

Email: hasanmohammad@doctors.org.uk

Corresponding Author Address: The Botnar Research Centre, Old Road, Oxford, OX3 7LD.

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ABSTRACT

Background: Lateral unicompartmental knee replacement (UKR) is an alternative to total knee replacement for isolated lateral unicompartmental knee arthritis. The geometry and mechanics of the lateral compartment differ to the medial compartment with the Lateral Domed Oxford UKR designed to address this. We used National Joint Registry (NJR) data to report the mid to long term outcomes of this device.

Methods: We performed a retrospective observational study using NJR data on 992 Lateral Domed Oxford UKRs implanted between 1st January 2005 and 31st December 2017. Outcomes of interest were implant survival and revision indications.

Results: The 10 year cumulative implant survival rates were 88.6% (CI 85.3-91.2). When compared to <55 year age group, the 55-64, 65-74 and ≥75 groups had significantly lower revision rates (Hazard Ratio (HR)=0.56 (CI 0.32-0.98, p=0.04), HR 0.40 (CI 0.22-0.72, p=0.003) and HR 0.27 (CI 0.12-0.58, p=0.001) respectively). The obese group had significantly (p=0.04) increased revision risk compared to normal BMI (HR 2.33, CI 1.06-5.12). The commonest reasons for revision surgery were dislocation (n=23, 2.3%), pain (n=15, 1.5%) and aseptic loosening (n=14, 1.4%).

Conclusion: The Lateral Domed Oxford UKR provides a good option for isolated lateral compartment osteoarthritis. However dislocation of the mobile bearing remains a problem, occurring in 2.3% of the patients and accounting for 30% of the revisions. To help prevent dislocation it is now possible to assess bearing stability intra-operatively and if very unstable to implant a compatible fixed bearing tibial component, without the need for further bone preparation.

Key words: Lateral, Domed, Oxford UKR, Long term outcomes

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INTRODUCTION

Lateral unicompartmental knee replacement (UKR) is an alternative to total knee replacement (TKR) for isolated lateral unicompartmental knee arthritis which has failed to respond to conservative treatments [1]. Several studies have shown UKR has many advantages over TKR including preserved knee kinematics, better functional outcomes and lower mortality rates [2, 3], although the revision rate remains higher in the joint registries [4-6].

Isolated lateral compartment osteoarthritis is much rarer than medial compartment osteoarthritis [7]. As a result there are fewer published studies of lateral UKR than medial UKR and they tend to be smaller. The anatomy and kinematics of the lateral compartment are different to the medial compartment, which demands a different operative technique and ideally different implants [1]. The lateral tibial plateau is convex and in flexion there is significant movement of the lateral femoral condyle on the tibia such that in high flexion the femoral condyle articulates with the posterior tibial plateau [8]. In knee flexion the lateral ligaments are lax such that the lateral side can be distracted by on average 7 mm compared to 2 mm on the medial side [9]. The original design of mobile bearing lateral oxford UKR had a flat tibial plateau like the medial. The difference in distraction of the compartments resulted in the bearing dislocation rate on the lateral side being unacceptably high at approximately 10% and much higher than the dislocation rate on the medial side [1].

The cemented Lateral Domed Oxford UKR (Zimmer Biomet, Swindon) was introduced to address the high bearing dislocation rates. It consists of a tibial and femoral component made from cobalt chromium molybdenum alloy and a mobile polyethylene bearing. It has a convex tibial plateau, which more accurately reproduces the normal anatomy in the lateral compartment [8, 10, 11]. The fully congruent bearing is biconcave to articulate below with the convex spherical surface of the tibial plateau and above with the spherical surface of the femoral component. This results in increased entrapment of the bearing compared to the original flat lateral Oxford UKR, which should decrease the dislocation rate. The introduction of this implant and improvements in the surgical technique reduced the rate of bearing dislocation to 1.7%, in the first report from the designer surgeons [12]. However subsequent reports from the designers and other centres have reported variable dislocation rates between 1.5% and 6%, with many being the result of trauma [13-17].

The National Joint Registry of England, Wales, Northern Ireland and Isle of Man (NJR) is the largest arthroplasty register, but currently does not report the results of medial and lateral UKRs separately despite them being very different implants. We used NJR data to report the mid to long term outcomes of the largest Lateral Domed Oxford UKR cohort to date. Additionally we investigated the effect of age and body mass index on the implant's performance.

MATERIAL AND METHODS

After NJR subcommittee approval, a retrospective observational study using the NJR database was conducted. The NJR records all knee replacement operations performed in England, Wales, Northern Ireland and the Isle of Man and achieves high levels of patient consent. The NJR records various implant, patient and surgical factors from data capture forms completed by the operating surgeon or delegate for each knee replacement procedure. Unique patient identifiers allow for excellent link ability to subsequent revision surgeries [5]. The database is linked to mortality data from the Office for National Statistics.

Anonymised lateral Oxford UKR procedures performed between 1st January 2005 to 31st December 2017 from the NJR database were analysed. After data cleaning involving the removal of implants with missing and inconsistent components, there were 992 Lateral Domed Oxford UKRs eligible for study inclusion (Figure 1).

Study outcomes of interest were (1) 10 year implant survival, (2) implant survival in different age and body mass index groups at 5 years (given limitations in the number at risk at 10 years for subgroup population analyses) and (3) overall indications for revision surgery.

Cumulative implant survival was calculated using the Kaplan-Meier method with the endpoint for implant survival being any revision surgery in which any component was removed, exchanged or added. Patients were a priori split into: (1) age groups; < 55 years (n=234, 23.6%), 55-64 years (n=234, 23.6%), 65-74 years (n=291, 29.3%) and ≥ 75 years (n=233, 23.5%). (2) Body mass indexes (BMI) were categorised into underweight (<18.5kg/m^2), normal (18.5 to < 25kg/m^2), overweight (25 to <30kg/m^2) and obese (≥30kg/m^2). The numbers in each category were 1 (0.1%), 178 (17.9%), 335 (33.8%) and 273 (27.5%) respectively. 205 cases had no information on BMI and therefore could not be included in the BMI analysis. Cox regression models were used to compare the revision rates in different age and BMI groups with the proportional hazards assumption met in all analyses.

All statistical analyses were performed using Stata (Version 15.1; StataCorp, College Station, TX, USA). P-values of < 0.05 were considered significant, with 95% confidence intervals (CI) presented.

RESULTS

The cohort analysed consisted of 992 Lateral Domed Oxford UKRs inserted between 1st January 2005 and 31st December 2017 through a lateral parapatellar approach in 978 cases (98.6%). The primary indication for surgery was osteoarthritis in 969 knees (97.7%). The mean patient age and BMI at surgery was 64.5 years (SD 12.3) and 28.3 kg/m^2 (SD 5.0) respectively. 641 UKRs (64.6%) were implanted in female patients. The ASA grade was I in 302 cases (30.4%), II in 600 cases (60.5%) and III or above in 90 cases (9.1%). Primary thromboprophylaxis and mechanical prophylaxis was administered in 951 (95.9%) and 983 UKRs (99.1%) respectively.

The mean follow up for the Lateral Oxford Domed UKRs was 5.0 years (SD 3.0). In total, 77 knees (7.8%) underwent revision surgery. The 5 and 10 year cumulative implant survival rates were 92.4% (CI 90.3-94.1) and 88.6% (CI 85.3-91.2) respectively (Figure 2).

The 5 year implant survivals for the <55 years, 55-64 years, 65-74 years and ≥75 years groups were 86.0% (CI 80.2-90.3), 92.9% (CI 88.4-95.7), 94.9% (CI 91.3-97.1) and 95.6% (CI 91.1-97.8) (Figure 3). When compared to <55 year age group, the 55-64, 65-74 and ≥75 groups had significantly lower revision rates. The respective hazard ratios were; HR 0.56 (CI 0.32-0.98, p=0.04), HR 0.40 (CI 0.22-0.72, p=0.003) and HR 0.27 (CI 0.12-0.58, p=0.001).

The 5 year implant survivals for the normal weight, overweight and obese groups were 96.0% (CI 91.4-98.2), 92.3% (CI 88.3-95.0) and 89.7% (CI 84.8-93.1). There was only one patient in the underweight group, so this group could not be analysed. When compared to the normal weight group the overweight group had an increased risk of revision (HR 1.81, CI 0.82-4.01), but this was not statistically significant (p=0.14). The obese group did have a significantly (p=0.04) increased of revision compared to the normal group (HR 2.33, CI 1.06-5.12) (Figure 4).

Overall the four commonest reasons for revision surgery were dislocation/subluxation (n=23, 2.3%), pain (n=15, 1.5%), aseptic loosening (n=14, 1.4%) and arthritis progression (n=12, 1.2%). Revision for dislocation tended to occur early, at an average of 1.5 years, and osteoarthritis progression late, at an average of 5.2 years. From the 23 dislocation/subluxation revisions; 8 (3.4%) occurred in the <55 years group (n=234), 8 (3.4%) in the 55-64 years

group (n=234), 4 (1.4%) in the 65-74 years group (n=291) and 3 (1.3%) in the ≥75 age group (n=233).

DISCUSSION

This NJR based study reports the mid to long term outcomes of the largest cohort of the Lateral Domed Oxford UKR reported so far. The 10 year implant survival was 89%, which although is satisfactory and better than the original Flat Lateral Oxford UKR (67% at 10 years [1]), remains worse than that of the medial Oxford UKR (93.3%) reported by the NJR [18]. This is primarily due to the much higher rates of revision for dislocation/subluxation (2.3%) in the lateral compared to the medial compartment (0.3%) [18] .

The mobile bearing lateral Oxford UKR has always had an issue of bearing dislocation due to the complex anatomy in the lateral compartment. The main issue is that the lateral collateral ligaments are lax in flexion allowing the lateral compartment to distract on average 7 mm whereas the tighter medial collateral ligaments allows only 2 mm of distraction [9]. This makes the bearing more prone to dislocate in the lateral compartment. However for a dislocation to occur, not only does the compartment have to be distracted, but also something impinging on the bearing has to displace it. With the original Lateral Flat Oxford UKR, which was similar to the medial, the dislocation rate was about 10% [1]. However with the introduction of the Lateral Domed Oxford UKR, which has a biconcave bearing, with increased entrapment, the dislocation has dropped substantially [17].

The Lateral Domed Oxford UKR's bearing dislocation rate in our study was 2.3%, which is similar to other studies in the literature which report rates generally between 1.5-6% [12-17]. Dislocations can usually be treated successfully and without recurrence, by inserting a new bearing, usually one or two millimetres thicker, and ensuring there is no underling problem, such as a retained posterior osteophyte impinging on the bearing and causing it to dislocate [19]. Dislocations tend to occur early, and in our study the average time to dislocation was 1.5 years. This is presumably because fibrous tissue forms around the bearing and prevents it from dislocating. This fibrous tissue moves with the bearing and does not restrict its movement. As a result although dislocation is an issue early on it is less likely to be a problem in the long term.

Dislocation accounted for about 30% of the revisions of the Domed lateral in this study. To address the problem of dislocation a Fixed bearing Lateral Oxford (FLO) tibial component has been introduced, which can be used interchangeably with the domed lateral tibial

component, and both articulate with the same femoral component . We therefore recommend that before fixing the dome components the stability of the bearing is assessed intraoperatively. This is best done with the knee in the figure of four position with the trial femoral and tibial component in place. If the bearing can be easily dislocated it may be sensible to implant the FLO tibial component instead of a domed tibial component, which requires no additional bone preparation at primary surgery. The FLO tibial component is also useful for treating a recurrent bearing dislocation of the Lateral Domed Oxford UKR and can be used as an alternative to replacing the bearing for a primary dislocation. To revise a domed tibial component to a FLO tibial component, the domed tibial component is removed and, after the fixation surfaces are freshened, FLO tibial component is cemented in [13].

Although the Domed lateral UKR has the disadvantage of dislocation compared to FLO UKR it does have certain advantages. Given it has a mobile bearing the linear wear rate is substantially lower, so there are less likely to be problems related to wear in the long term, such as failure or deteriorating kinematics [20-23]. Additionally the convex shape of the Domed tibia restores the normal anatomy better than a flat surface and allows the lateral femoral condyle to move in a normal fashion posteriorly and inferiorly over the posterior tibial plateau [8, 10, 11]. As a result the kinematics are more normal. In particular with the Domed lateral, higher flexion is achieved and this is associated with normal rather than restricted roll back [19]. In addition there is evidence that there is less pain with a Domed rather than a flat tibia perhaps because the ligaments are stretched less in flexion [12].

This analysis of NJR data found that about a quarter of patients treated with the Domed lateral were under 55, which is more than expected with medial UKR series [24] and far more than in TKR [5]. Many patients were very young, which is perhaps a reflection of the speed at which arthritis can develop after lateral meniscal damage or meniscectomy. This <55 year old group had a significantly higher risk of revision than the older age groups. As well as finding the revision rate increased with decreasing age, we found that obese patients were significantly more likely to be revised than the normal weight groups. This is similar to the data reported for all UKR and all TKR in the registries [4, 5]. Many believe this is due to younger patients being more active and obese patients putting more strain on the implant, making them more prone to mechanical failure, but previous work has shown this is not the case for the Oxford medial UKR [24, 25]. For this device the high revision rate in the young may be because it being used inappropriately in patients with early arthritis, without bone-on-

bone, who do not do well with joint replacement. Unfortunately the specific indications for surgery cannot be assessed using registry data. As a result age and BMI are not considered to be contraindications to the lateral UKR.

Our study does have its limitations. Given it is based on registry data it does not assess functional outcomes. Additionally the reasons for revision recorded in the NJR reflect those at the time of surgery and can subsequently change due to histopathology or microbiology data. Registries can also sometimes under-report revisions. There was also a substantial proportion of BMI data missing (n=205) and hence these patients could not be included in the BMI subgroup analyses of implant performance but this did not affect our overall analyses and age subgroup analyses. Finally we are unable to see the exact indications for lateral UKR surgery as we do not have the clinical notes or radiographs of the patients in this cohort.

CONCLUSIONS

In conclusion we found that the 10 year implant survival of the Lateral Domed Oxford UKR is 89% and it provides a good treatment option for isolated lateral compartment osteoarthritis. However, about 30% of the revisions were due to bearing dislocation which occurred in 2.3% of cases. With the introduction of the FLO tibial component, which can be used interchangeably with the dome tibial component, it is now possible to assess bearing stability intra-operatively and insert a FLO tibial component, if the bearing can easily be dislocated.

336 **Table 1. Reasons for revision in matched cohort**. Abbreviations: OA (Osteoarthritis), UKR

337 (Unicompartmental Knee Replacement).

Revision indication	Lateral UKRs (n=992, 100%)	Mean time to revision indication (years)
Dislocation subluxation revision	23 (2.3%)	1.5 (SD 1.6)
Pain	15 (1.5%)	2.6 (SD 2.4)
Aseptic loosening	14 (1.4%)	2.9 (SD 2.1)
Other	14 (1.4%)	2.6 (SD 2.6)
OA progression	12 (1.2%)	5.2 (SD 3.1)
Component dissociation	6 (0.6%)	1.3 (SD 1.7)
Infection	6 (0.6%)	2.0 (SD 2.1)
Instability	3 (0.3%)	3.8 (SD 2.7)
Periprosthetic fracture	1 (0.1%)	4.0
Lysis	1 (0.1%)	4.5
Wear	1 (0.1%)	1.5
Stiffness	1 (0.1%)	3.4

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LIST OF FIGURES

REFERENCES

1. Gunther T, Murray D, Miller R, Wallace D, Carr A, O'Connor J, McLardy-Smith P, Goodfellow J. Lateral unicompartmental arthroplasty with the Oxford meniscal knee. Knee 3(1-2): 33, 1996

2. Wilson HA, Middleton R, Abram SG, Smith S, Alvand A, Jackson WF, Bottomley N, Hopewell S, Price AJ. Patient relevant outcomes of unicompartmental versus total knee replacement: systematic review and meta-analysis. BMJ 364: l352, 2019

3. Liddle AD, Judge A, Pandit H, Murray DW. Adverse outcomes after total and unicompartmental knee replacement in 101 330 matched patients: a study of data from the National Joint Registry for England and Wales. Lancet 384(9952): 1437, 2014

4. Australian Orthopaedic Association. Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip, Knee & Shoulder Arthroplasty. 2018

5. National Joint Registry. National Joint Registry 15th Annual Report. National joint registry for England, Wales Northern Ireland and Isle of Man. [Accessed on 12/1/2019]. 2018

6. The New Zealand Joint Registry. Seventeen Year Report January 1999 to December 2015. New Zealand Joint Registry 2016

7. White S, Ludkowski P, Goodfellow J. Anteromedial osteoarthritis of the knee. Bone Joint J 73(4): 582, 1991

8. Nakagawa S, Kadoya Y, Todo S, Kobayashi A, Sakamoto H, Freeman M, Yamano Y. Tibiofemoral movement 3: full flexion in the living knee studied by MRI. Bone Joint J 82(8): 1199, 2000

9. Tokuhara Y, Kadoya Y, Nakagawa S, Kobayashi A, Takaoka K. The flexion gap in normal knees: an MRI study. Bone Joint J 86(8): 1133, 2004

10. Iwaki H, Pinskerova V, Freeman M. Tibiofemoral movement 1: the shapes and relative movements of the femur and tibia in the unloaded cadaver knee. Bone Joint J 82(8): 1189, 2000

11. O'connor J, Shercliff T, Biden E, Goodfellow J. The geometry of the knee in the sagittal plane. Proc Inst Mech Eng H 203(4): 223, 1989

12. Pandit H, Jenkins C, Beard D, Price A, Gill H, Dodd C, Murray D. Mobile bearing dislocation in lateral unicompartmental knee replacement. Knee 17(6): 392, 2010

13. Weston-Simons J, Pandit H, Kendrick B, Jenkins C, Barker K, Dodd C, Murray D. The mid-term outcomes of the Oxford Domed Lateral unicompartmental knee replacement. Bone Joint J 96(1): 59, 2014

14. Schelfaut S, Beckers L, Verdonk P, Bellemans J, Victor J. The risk of bearing dislocation in lateral unicompartmental knee arthroplasty using a mobile biconcave design. Knee Surg Sports Traumatol Arthrosc 21(11): 2487, 2013

15. Fornell S, Prada E, Barrena P, García-Mendoza A, Borrego E, Domecq G. Mid-term outcomes of mobile-bearing lateral unicompartmental knee arthroplasty. Knee 25(6): 1206, 2018

16. Newman SD, Altuntas A, Alsop H, Cobb JP. Up to 10 year follow-up of the Oxford Domed Lateral Partial Knee Replacement from an independent centre. Knee 24(6): 1414, 2017

17. Walker T, Zahn N, Bruckner T, Streit M, Mohr G, Aldinger P, Clarius M, Gotterbarm T. Mid-term results of lateral unicondylar mobile bearing knee arthroplasty: a multicentre study of 363 cases. Bone Joint J 100(1): 42, 2018

18. Mohammad HR, Matharu GS, Judge A, Murray DW. Comparison of the 10-year outcomes of cemented and cementless unicompartmental knee replacements: data from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. Acta Orthop: 1, 2019

19. Goodfellow J, O'Connor J, Pandit H, Dodd C, Murray D. Unicompartmental Arthroplasty With The Oxford Knee: Goodfellow Publishers Ltd, 2016

20. Mohammad HR, Campi S, Kennedy JA, Judge A, Murray DW, Mellon SJ. Long-term in vivo wear of different bearing types used for the Oxford Unicompartmental Knee Replacement. Bone Joint Res 8(11): 535, 2019

21. Lavernia CJ, Sierra RJ, Hungerford DS, Krackow K. Activity level and wear in total knee arthroplasty: a study of autopsy retrieved specimens. J Arthroplasty 16(4): 446, 2001

22. Ashraf T, Newman J, Desai V, Beard D, Nevelos J. Polyethylene wear in a non-congruous unicompartmental knee replacement: a retrieval analysis. Knee 11(3): 177, 2004

23. Kendrick B, Simpson D, Kaptein B, Valstar E, Gill H, Murray D, Price A. Polyethylene wear of mobile-bearing unicompartmental knee replacement at 20 years. Bone Joint J 93(4): 470, 2011

24. Kennedy JA, Matharu GS, Hamilton TW, Mellon SJ, Murray DW. Age and outcomes of medial meniscal-bearing unicompartmental knee arthroplasty. J Arthroplasty 33(10): 3153, 2018

25. Molloy J, Kennedy J, Jenkins C, Mellon S, Dodd C, Murray D. Obesity should not be considered a contraindication to medial Oxford UKA: long-term patient-reported outcomes and implant survival in 1000 knees. Knee Surg Sports Traumatol Arthrosc 27(7): 2259, 2019